Introduction to NEMS

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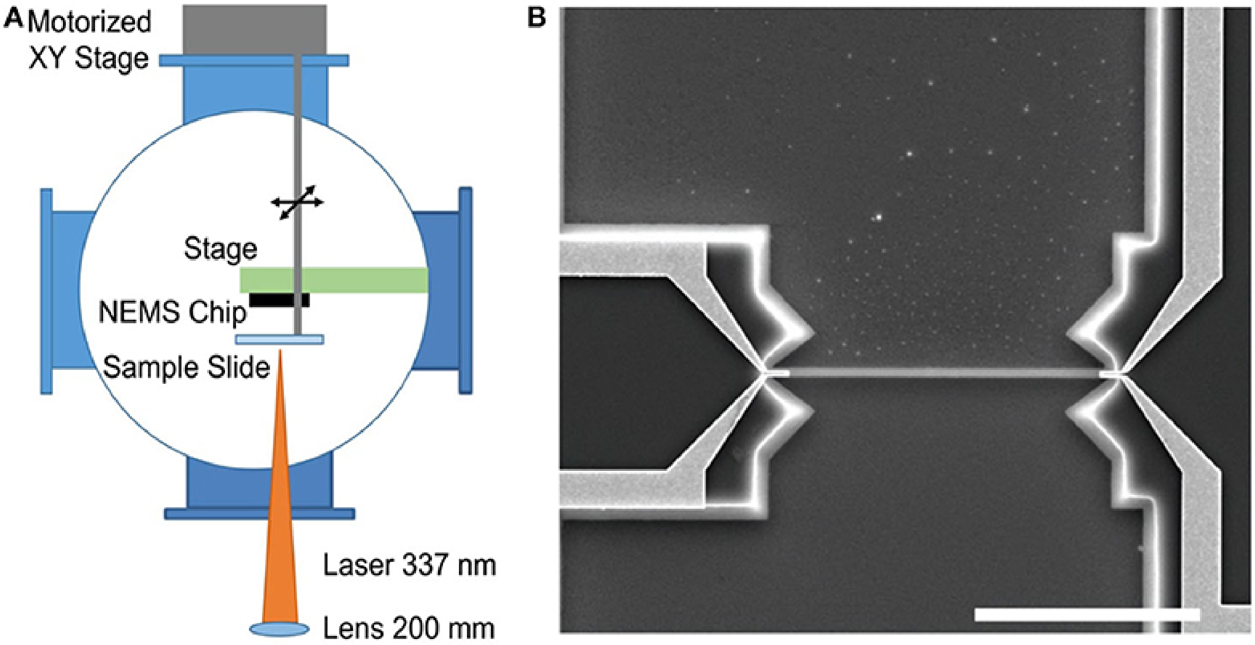
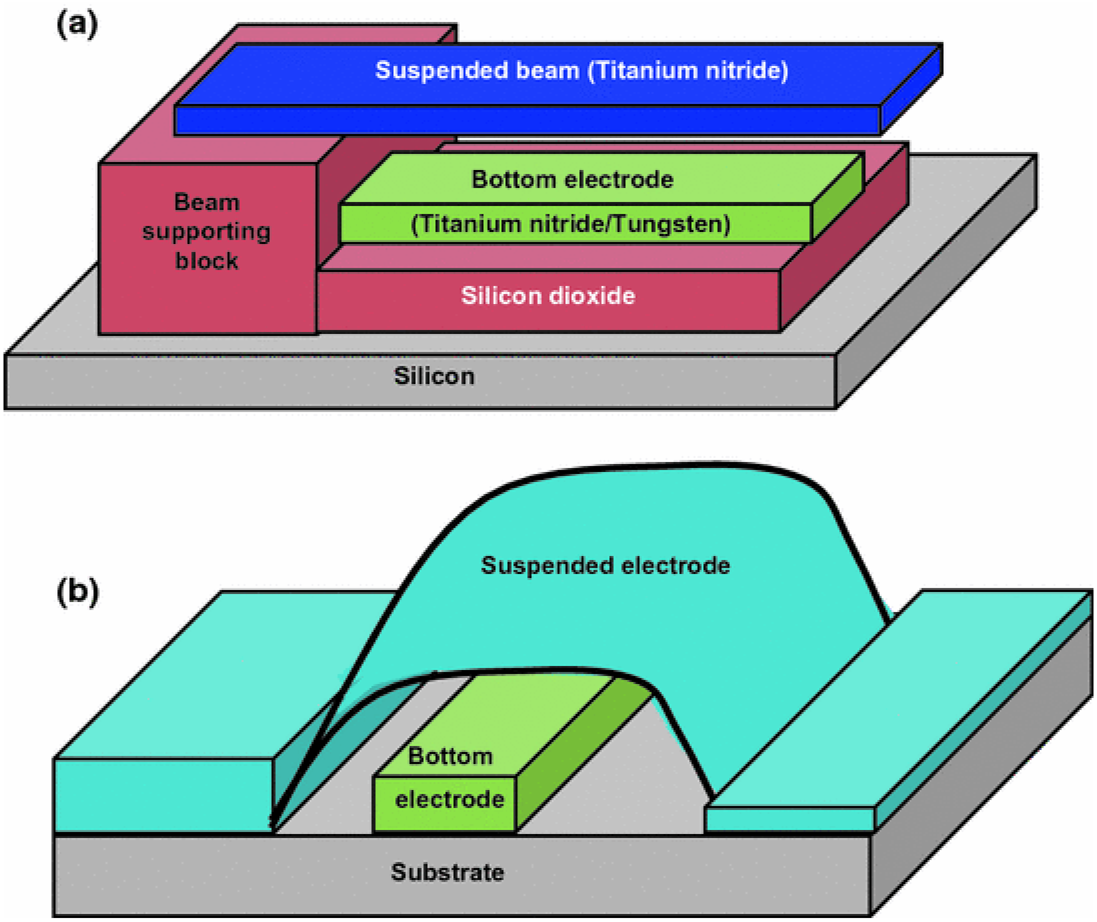
Nanoelectromechanical systems (NEMS) are a class of devices that combine electrical and nanoscale devices. NEMS makes the next step in miniaturization from so-called microelectromechanical systems, or MEMS devices.

Introduction

NEMS are very important for the development of integrated devices. The idea is that if we use different materials, not only the standard semiconductors, metals and dielectrics, and we process them in such a way to integrate all together very complex structures, which could be even active, even in motion, we were able to realize something which is normally macroscopic. Reducing it to the microscale, there are two interesting phenomena that occur. First one, we have access to something, which is not really feasible on the macroscopic scale. For example, you can even extract energy from the Brownian motion of molecules. Thermodynamically speaking, it's difficult to do it at a macroscopic scale. As a second positive thing, we are able to scale down and reduce power consumption, volume mass, which is something very critical towards space. Micro electronics gave us the tools to process silicon at the microscale, using optical lithography, and wet etching, dry etching, deposition. All those processes allowed structuring and create a geometry, very complex geometry, of the two-dimensional surface. Of course, if we repeat the process, we may have access even to the third dimension, which is perpendicular to that plane, and we eventually gain the opportunity to realize massive bulk and volume structures, scaled down to the microscale. So, actually it's very essential to understand what's the material category, what kind of function one can realize with the different materials and how one can integrate them in a single device, in order to design new applications. So, material science is something that connects together the structure of the materials to the properties they have. While materials engineering connect together the processing, standard processing of the materials, with the properties they have. So, it's indispensable to have knowledge of both fields in order to start from the material, deposit it or process or structure it by means of industrial tools available, and finally end up with the device that has the properties that correctly address all the requirements we have. This is a sort of systematic study.

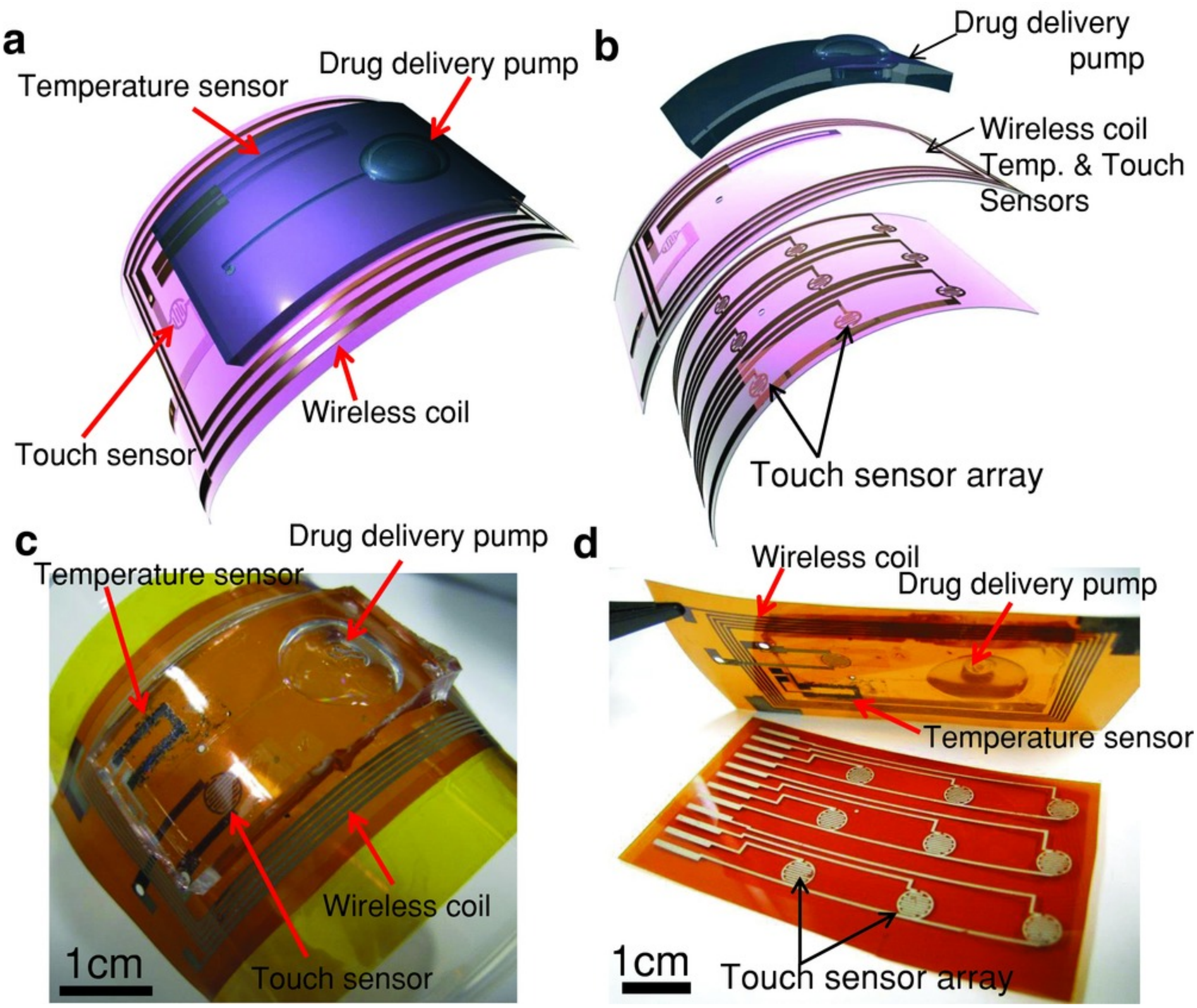
A few applications of NEMS include NEM accelerometer, NEM switches, NEMS mass spectrometer, and in various Integrated Circuits.





NEMS in Wearable Devices

Smartwatches, fitness trackers, smart garment's, smart medical attachments. The market for wearable electronics is quickly evolving beyond fitness and healthcare into infotainment and commercial and industrial applications. Wearable electronics consist of several areas: sensors and actuators and power supply. The key challenge is the requirement to achieve and combine different properties like flexibility, user comfort and everything for the device to be miniaturized and fashionable. To do this, researchers are making use of different materials like carbon nanotubes, graphene polymers and dielectric elastomers.

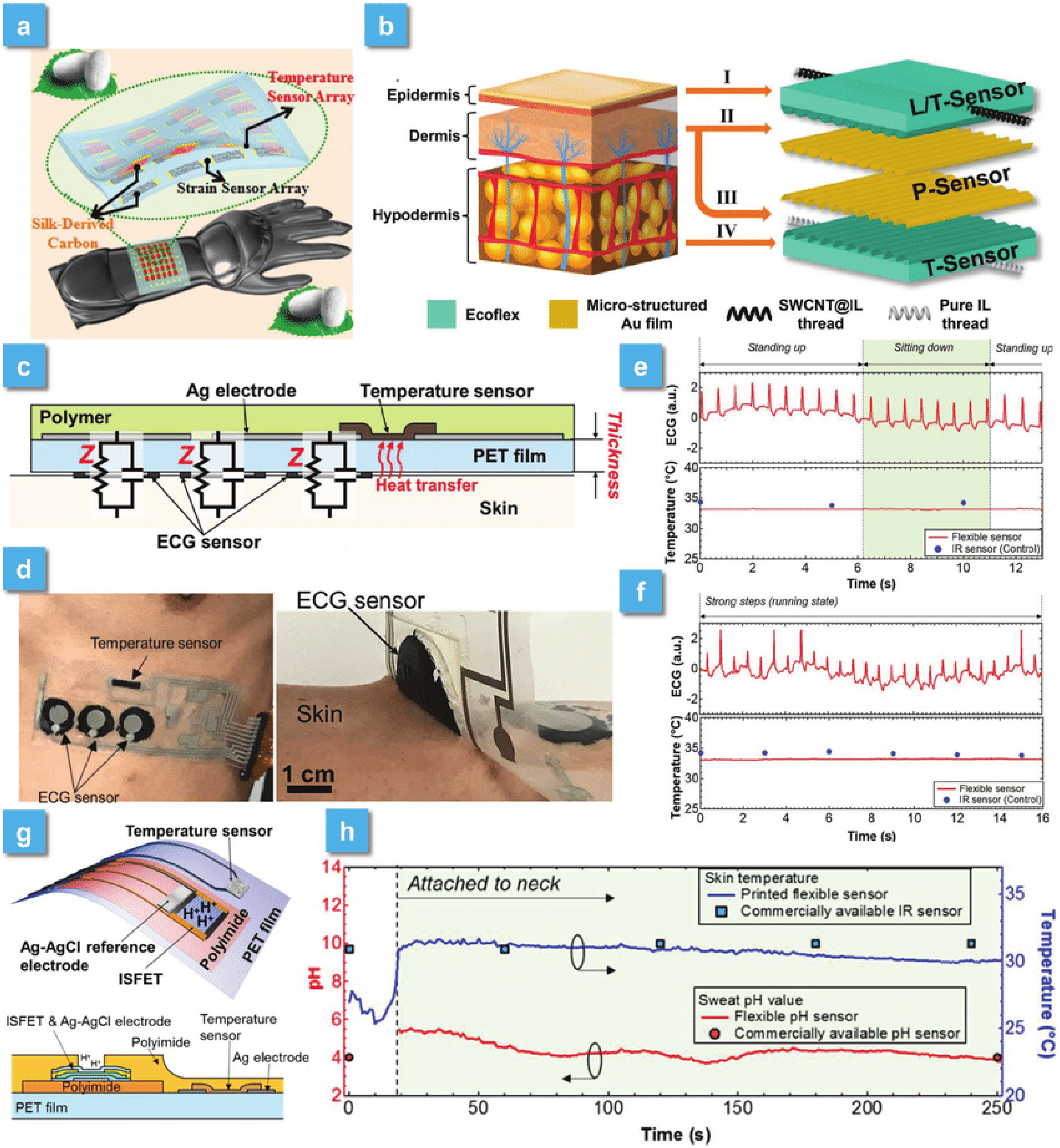


Construction and working

These devices are constructed using many barb-like sensors, actuators etc. Nanomaterial sensors sense an external stimulus and convert it into a measurable signal coma which can later be transferred to a processing unit or a monitoring device. The appearance of sensors in our daily life has revolutionized human living quality. Take a modern smartphone. It can precisely fix aggregate and display position and orientation for users by integrating many sensors like gyroscope and accelerometer, magnetometer and barometers in concert. But most variable sensors are expected to be the most practicable and prospective applications in the near future.

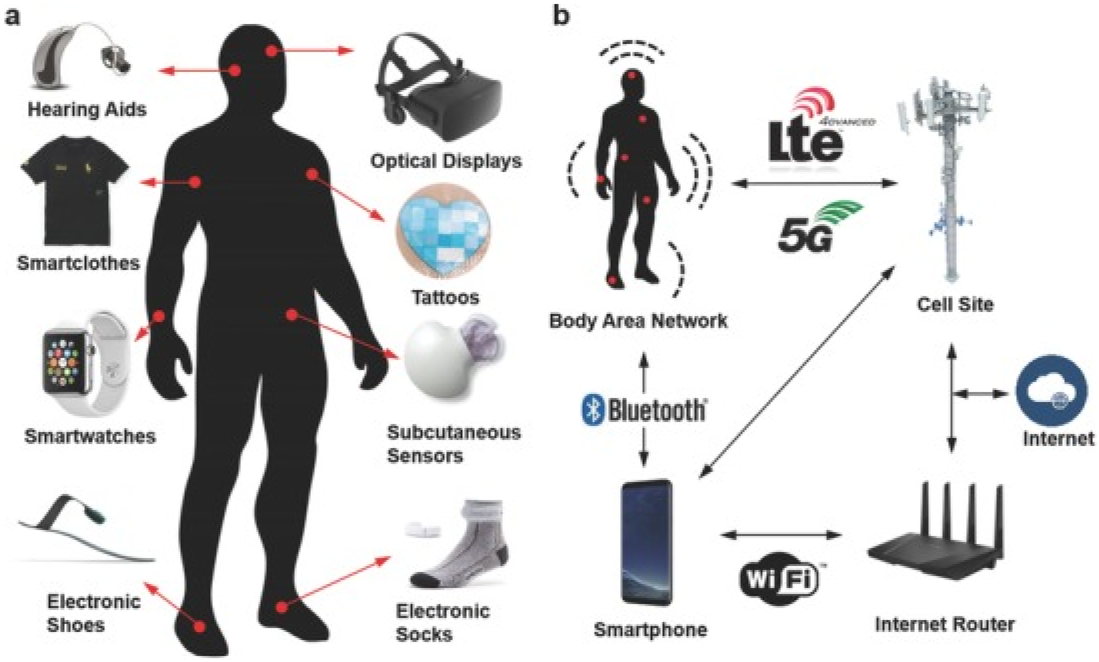
The flexibility and consistency of traditional sensor systems based on rigid metal and semiconductor materials makes them largely unsuitable for wearable sensors.

Wearable sensors require novel approaches in material and structure designs to possess high flexibility, sensitivity, and wide sensing range. This led researchers to explore nanocomposites and nanomaterials for wearable sensors. The choice of nanomaterials for wearable sensors mainly considered as material properties processing technology and the possibility of large scale production specifically 1D Nanomaterials and Nanocomposites including metallic nanowires and nanotubes are being extensively used.



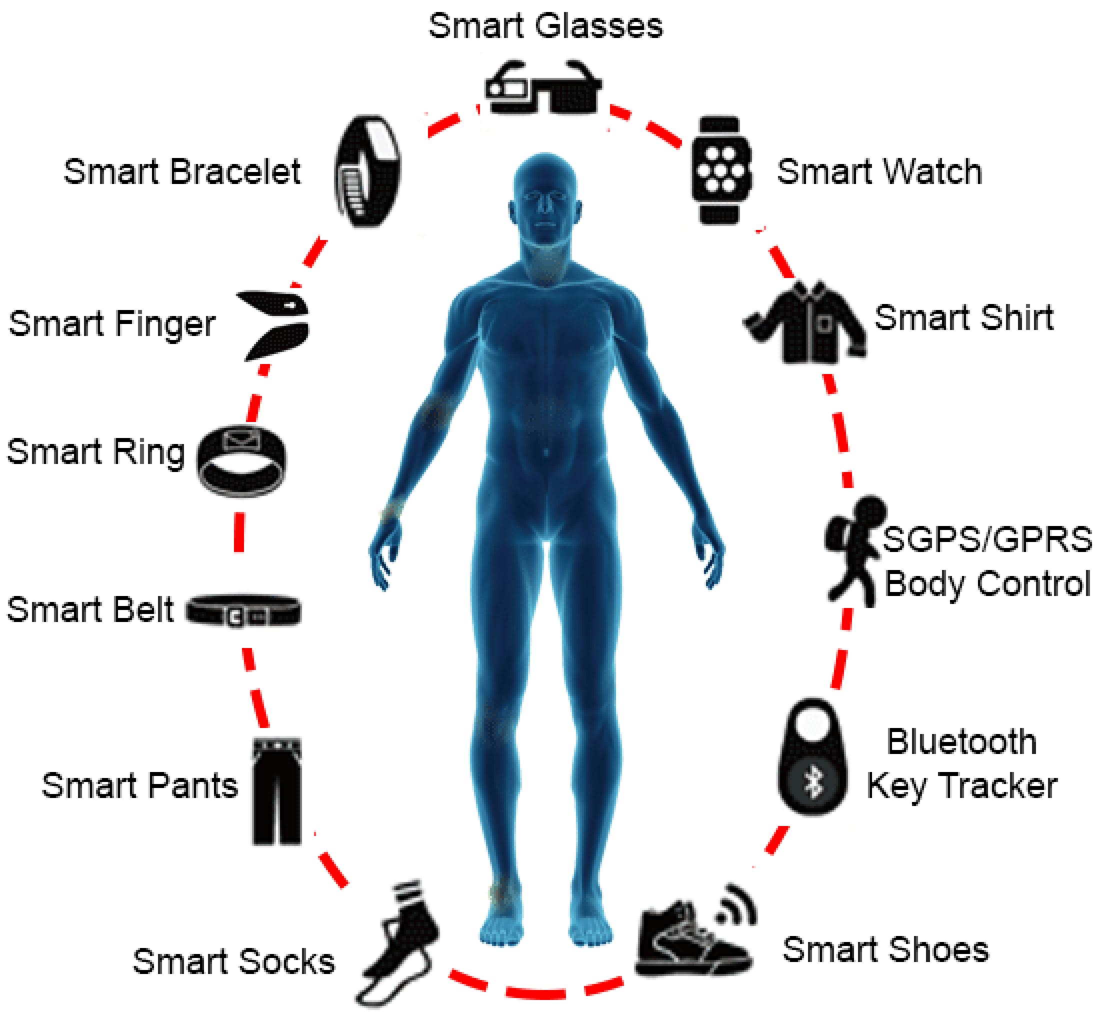
Already researchers have demonstrated various innovative wearable sensors with excellent performance by synthesizing nanomaterials and nanocomposites incorporating existing nanomaterials: screen motion sensors, pressure sensors, temperature sensors.

These wearable sensors can be placed on or embedded in clothes or attached to parts of the body like finger, wrist, arm, throat, chest and leg. Others can be embedded into wearing accessories such as gloves, watches, earrings and necklaces, broaches and so on.



Development

The development of e-textiles and smart fabrics has broadened the application of variable actuators. Contributions to this development have heating elements embedded in variables and Nanocomposite based therapeutic devices, artificial muscles and muscular actuators, rehabilitation devices available and drug delivery systems. In order to obtain large-scale stretchability of nanomaterials apart from using all intrinsic structural materials, many researchers have adopted advanced structural design strategies to improve system level formation behavior.



Current status in the Research, Market and Society

The number and variety of smart textiles and wearable electronics has increased significantly in the past few years as they offer significant enhancement to human comforts health and well-being. Wearable low-power silicon electronics, LED fabricated on fabrics textiles with integrated lithium-ion batteries and electronic devices such as smart glasses, watches and lenses, have been widely investigated and commercialized (e.g., Google Glasses, Apple Watch). There is increasing demand for wearable electronics from industries such as:

1-Medical and health care monitoring and diagnostics
2-Sportswear and fitness monitoring (bands)

3-Consumer electronics such as smartwatches, smart glasses and headsets.

4-Military cuffs trackers, equipment (helmets) and wearable robots.

5-Smart apparel and footwear in fashion and sport.

6-Workplace safety and manufacturing.

However, improvements in sensors, flexible and printable electronic and energy devices are necessary for wider implementation and nanomaterials for their hybrids are enabling the next phase convergence of textiles, electronics, and informatics. They are opening the way for the integration of electronics components and sensors (e.g., Heat and humidity) in high strength, flexible and conductive textiles with energy storage and harvesting capabilities, biological functions for antimicrobial properties and many other new functionalities.

The industry is now moving towards the development of electronic devices which are flexible, thin, and large.

Conclusion

Significant barriers currently hindering the commercial use of many NEMS devices include low yields and high-quality device variability. Before NEMS devices can be used, a reasonable combination of carbon-based products must be created. The latest step in that process is illustrated with a diamond, which achieves a level of processing comparable to that of silicon. The current focus shifts from the experimental work to the actual applications and device structures that will use and benefit from those novel devices.

Carbon-based materials have served as the main tools for the use of NEMS, due to their unique mechanical and electrical properties.

NEMS global market is expected to reach $108.88 million by 2022.

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